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NOTE ON THE TIDAL BORE.

BROOKLYN, March 25th, 1902.

EDITOR BULLETIN:

Will you allow me a few words in relation to the following quotation, taken from *The Solution of the Problem of the Tidal Bore*, published recently in No. 4, page 319:

> Whence does this energy come [the energy of the bore]? Now, I say that it comes from the rotation of the earth.
>
> THE TIDES.
>
> His [Mr. Darwin's] third attempt to solve the problem comes to us as a great surprise; and, strangely enough, it stands without the support of a single reason, or of an observed fact, to prove it in *The Tides*; therefore, it is merely a personal opinion, and nothing more.

I wish to state that those familiar with the results obtained in the use of large centrifugal machines will not agree with this conclusion. If permitted, I should like to detail experiments that, I think, tend to prove the original statement.

One of these would show results obtained when the centrifugal force alone was in control; the second, on the contrary, would call in a disturbing cause, thus showing the effect of an interference with the same centrifugal force. This interfering influence would represent, under the actual conditions, the attractions of some heavenly body, such as the sun or moon, both of which, we know, cause a tidal cap to follow their movements.

Let us turn to the simpler experiment, *i. e.*, when the centrifugal force alone is in control, for our desire is to contrast the results of this with the second. The apparatus best suited to our purpose is an ordinary centrifugal for the working of sugar magma, a semi-fluid. This latter is composed of crystals and concentrated syrup. In the largest size of apparatus the charge is about 1,500 lbs., and about seventy-five horse-power is required to start the apparatus as it is generally used. The purpose of the process is to separate the crystals from the syrup, and in so doing the magma is thrown against the circumference of the revolving basket, the direction in which it is thrown and its distribution in this basket indicating the direction of the stresses reigning therein; on this account it answers our purpose completely, for we are seeking the results of the application of such forces to fluids, and the semi-fluids employed simply facilitate the matter because they move slower.

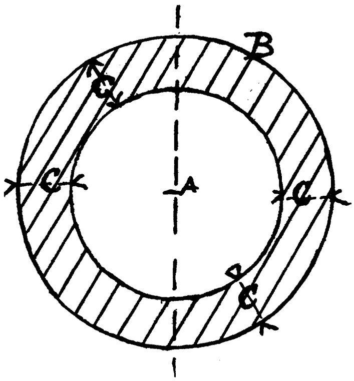
As the circumference is perforated with numberless holes the syrup escapes, leaving the crystals quite compactly in place, and recording, as stated, the influences they have been subjected to. To begin the trial the magma is run into the cylindrical basket, filling it about one quarter full. Then the power is applied and the basket begins to revolve, first slowly, then with rapidly-increasing velocity. The basket is suspended in such a manner that it can oscillate somewhat, its bearings being fitted with rubber springs, which can yield slightly in all directions.

Under the action of the centrifugal force the upper surface of the magma becomes more and more depressed at the centre, the mass moving so as to place itself at the greatest possible distance from this point, until finally it wedges itself against the walls at the circumference, standing vertically. When the maximum velocity has been acquired, we hear the syrup being thrown off, and in a few seconds the apparatus can be stopped. The crystals, no longer floating, ordinarily retain their relative positions and can be inspected at leisure.

It is important that we should appreciate just what has taken place. We are usually more impressed with results when we feel them acting directly upon our system. Hence a comparison tending to make us realize the energy involved in a sudden impulse we have thus experienced will aid us to take in the whole situation ; in consequence we note that the impulse upon the independent crystals by the centrifugal force can be compared with our personal experiences when we find ourselves standing among a number of passengers, in a vehicle in rapid motion just as the brakes are suddenly applied.

The results are unmistakable, for we find ourselves hurried forward to the limit of motion and pressed against the retaining walls.

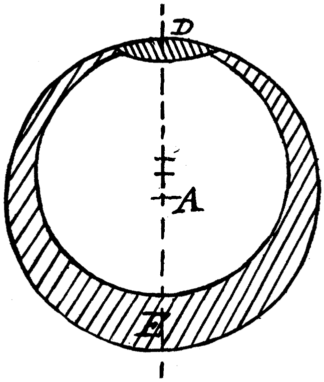
If we should, while in this position, have a photographic snap-shot taken of the crowd, the results would be comparable to the view obtained representing the positions of the crystals, hurled in their several directions and left stranded by the syrup ; this act instantly converting our semi-fluid into a fixed mass.



Our first experiment, as described, is performed thousands of times daily in the ordinary course of manufacture; the results are constant and well known.

If we represent a horizontal section through the basket by a circle, having the circumference at B, and the centre of motion at A, we find the standing wall of sugar can be shown by a second circle, drawn concentrically with the first ; for the distribution of sugar at all points is found to be even, and its thickness, C, the same everywhere.

We now come to the variation of our experiment, the introduction of a disturbing cause, an imitation, in our small way, of the effect produced by the sun or moon upon the fluids found upon the surface of the earth when subject to rotation. Our purpose is to compare the distribution of sugar particles found under the new conditions with the above, and to note their motion relative to the weight D. This latter we secure to the basket to represent an unequally distributed or local load, the weight of a tidal cap. No other change to the apparatus is required. The experiment can commence.



We find immediately that the oscillations of the basket are more violent, possibly dangerously so ; finally, upon repeated trial, we discover that the weight of D cannot exceed a fixed proportion of the weight of the charge without excessive oscillation ; even then the apparatus must be started with judgment and skill, or it may damage itself.

The point A, the mechanical centre of the basket, is seen to revolve in a circle ; as the charge is distributing itself through the basket, this circle described by A becomes gradually smaller in diameter ; in the same measure the speed can be increased until the point A runs true or is apparently stationary, when full speed can be reached ; the syrup purges as before and the operation is complete; the basket can be stopped and the contents examined. The distribution is found as shown at E on sketch, where the maximum thickness is located on a line diametrically opposed to the weight D. It becomes evident that the oscillations which were threatening at the start, caused an attempt to counterbalance the weight D; this it was necessary to do gradually before the speed could be much increased; it became possible when a limit was found, and it was ascertained that this weight must be reduced until it could be counterbalanced by the weight of the charge, in such positions as it could reach, under existing conditions.

When all these conditions were arrived at the experiment could be completed.

Now, it is well understood what laws were acting within the machine, and why the distribution was as found; it is argued that precisely similar results must follow in the larger-scale phenomenon we are attempting to imitate. It is obvious that in attaching the weight D to the basket we have altered its centre of gravity, and it is well understood that in attempting to start the apparatus with the weight D as well as the charge, the basket must revolve upon the new centre of gravity of the rotating mass; evidently this could no longer correspond with the mechanical centre of the basket, hence the motion of this latter point A in a circle around the new centre of gravity. During this oscillation the basket was moving in an ever-changing plane; it is a well-known fact, shown by the gyrostat, that when a revolving mass is forced to move from its plane of revolution a stress is introduced endeavouring to cause it to return thereto, and when brought back tending to produce that sense of quasi-rigidity against further movement; while being forced back, however, this stress reigns throughout the whole mass. In this case the semi-fluid masses responded. The oscillation in the manner described, sent out our little passengers, the sugar particles, where we found them doing this work, counterbalancing the disturbing cause. We saw the remedy was effective, because the circles that A was describing were gradually reduced in size, until the point A ran true, with quasi-rigidity, and the effort of D was counterbalanced.

Thus a second wave was formed, diametrically opposed to the point of application of D, and of equal size, as far as the materials were provided to form the same. From this it would apparently follow that when a tidal cap is produced upon a rotating body, and a fluid mass is situated thereon, the latter endeavours, to the extent of its ability, to counterbalance the moving weight.

Carried to its extreme, this means that, aided by the rotation, the Diurnal wave will produce the Semi-Diurnal, or any part thereof permitted by the surrounding conditions. This latter may be a bore limited to such fluid masses as the circumstances permit of.

As regards the expenditure of energy in maintaining the original wave, it is evident that, owing to the presence and reaction between two heavenly bodies, say the earth and the moon, equal amounts of energy are being continually produced and expended in each.

Practically, then, the rotation of the earth produces the original wave; with this in existence we have shown how the companion is produced and maintained. Upon close inspection the thickness of the counterbalancing deposit, in the last experiment, is found to taper off gradually, in the basket, in both directions. This is an indication that, under the stress, material is furnished equally from both sides, and that there is no liability to furnish an excess in or by the direction of motion. There is, then, equal reason to expect a bore from the west as from the east.

It is evident that if either wave be temporarily arrested by obstructions in its path the existence of the second will tend reciprocally to aid in the reproduction of its companion, by the law, as shown. Either wave may be arrested to such an extent that the remainder, continuing upon its course, may be recognized as a bore, but its energy in either case comes from the rotation of the earth's mass. One of the conditions controlling its size is the extent of the companion wave existing in the plane of rotation and distant 180 degrees.

The approach of an ordinary ocean billow to an extended coast can be likened, as a miniature process, to that of one of these tidal waves.

Its source of energy is, to be sure, the winds of heavens, instead of the rotation of the earth, while both can be increased and decreased by the former agent; but in neither phenomenon can the expenditure of energy, by the pounding upon the coasts or into sinks, be mistaken as the cause. The arrival of one of these ocean rollers upon the variegated obstructions of a rocky coast, when watched from the beach, would seem to account for all the vagaries of any bore.

At one instant we see the main wave variously subdivided, forcing its way through obstructed channels, reach the shore in such a manner that the energy of the parts seems added together, and it shows a maximum effort; a second later another subdivides and the parts reunite so that their energies are antagonistic. The result is a minimum.

The number of possible changes between these extremes is endless, and the changes apparently inexplicable.

JOHN V. V. BOORAEM.